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ABSTRACT

This paper describes the development of a Web-based literacy learning software application, Technology Enhanced Learning Environment on the Web (TELE-Web). TELE-Web was developed based on the curriculum of the Early Literacy Project (ELP), an existing literacy program for elementary school students. In describing the development of TELE-Web, the paper adopts an emerging perspective on technology and established practices in education and literacy. This perspective explores how technology is affected by literacy practices in educational contexts, instead of concentrating only on technology's impact on practice. The paper is divided into five sections: the first section discusses the established practice, particularly the literacy goals and the believed effective approach to reaching the goals; the second section describes how technology extends the existing practice; the third section examines the affordances and constraints of the technological innovation to be applied; the fourth section describes the results of the dialogue between technology and established practices--the product; and the fifth section summarizes the discussions and concludes the paper. Contains 32 references and 4 figures representing screen images from TELE-Web. (RS)

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CIERA REPORT

TELE-Web

Developing a Web-Based Literacy Learning Environment

Yong Zhao, Carol Sue Englert, Jing Chen, Su Chin Jones,
and Richard Ferdig
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TELE-Web: Developing a Web-Based Literacy Learning Environment

CIERA REPORT #1-005

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CIERA Inquiry 1: Readers and Texts
Can a Web-based literacy learning software application accelerate early literacy achievement? How can existing educational practices inform the development of such applications?

This paper describes the development of a Web-based literacy learning software application, Technology Enhanced Learning Environment on the Web (TELE-Web). TELE-Web was developed based on the curriculum of the Early Literacy Project (ELP), an existing literacy program for elementary school students. In describing the development of TELE-Web, the authors adopt an emerging perspective on technology and established practices in education and literacy. This perspective explores how technology is affected by literacy practices in educational contexts, instead of concentrating only on technology's impact on practice.

Center for the Improvement of Early Reading Achievement
University of Michigan – Ann Arbor

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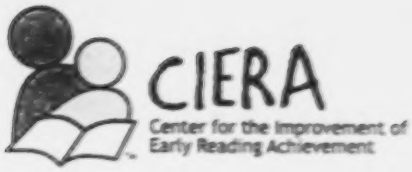

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TELE-Web: Developing a Web-Based Literacy Learning Environment:

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The nature of the relationship between technological innovation and established literacy practices in education has been a topic of many scholarly efforts. Traditionally, the relationship between technology and literacy practices is conceived as unidirectional, each being the independent variable affecting or affected by the other unidirectionally. This orientation leads to two contradictory effects-oriented discourses, technological determinism and social determinism (Bromley, 1997; Bruce, 1993; Bruce & Hogan, 1998). A more recent perspective sees the relationship as bidirectional or circular, in that technology and literacy or educational practices serve and inspire each other in reciprocal ways (Bromley, 1997; Bruce, 1993, 1997; Bruce & Hogan, 1998; Salomon & Almog, 1998).

This paper takes a reciprocal perspective in its description of an effort to develop a World Wide Web-based literacy learning environment. Instead of concentrating only on the effects of technology on literacy and literacy education, this paper also explores how technology is affected by literacy practices in educational contexts. We adopt this view not only because it seems to be a more accurate reflection of reality but also because it gives more agency to the practitioners of established practices faced with technological changes. Simply focusing on the effects of technology implies that technology acts upon established practices, in which case, the best that researchers can do is understand the effects and perhaps minimize their negative impacts and maximize their positive ones. To view the relationship between technological innovations and established practices as a dialogic process, however, suggests a much more dynamic and active role for established practices. Instead of only reacting to the "effects" of the innovation, an established practice can and does recursively affect the innovation as well.

A reciprocal view of technology and established practices thus provides the basis for a more productive framework for designing and implementing technological applications for literacy instruction and learning. This framework considers educational applications of technology, including designing and developing educational software, as a continuous trial-and-error process in which three sets of factors act upon each other to achieve an optimal balance of power. The three sets of factors are (a) the constraints and affordances of the technology, (b) the educational goals and available theories

about effective approaches, and (c) the social context in which the technology is applied.

The remainder of this paper looks at the development of a Web-based literacy environment from this perspective. The environment, Technology Enhanced Literacy Environments on the Web (TELE-Web), was developed based on an existing approach toward literacy development for students with mild disabilities at the primary grades (described below). The paper is divided into five sections. The first section discusses the established practice, particularly the literacy goals and the believed effective approach to reaching the goals. The second section describes how technology extends the existing practice. The third section examines the affordances and constraints of the technological innovation to be applied. The fourth section describes the results of the dialogue between technology and established practices—the product. The fifth and final section summarizes the discussions and concludes the paper.

The Established Practice: The Early Literacy Project

The curriculum of the Early Literacy Project (ELP) (Englert, Raphael, & Mariage, 1994), designed for use in primary-grade classrooms for students with learning disabilities, was intended to build literacy skills and impart learning-to-learn strategies. The curricular activities involved multiple forms of oral and written literacy, including (a) choral reading and partner reading of various texts; (b) summarizing and mapping expository and narrative stories that were part of thematic units; (c) participating in learning-to-learn processes as part of a report-writing process (e.g., brainstorming ideas, organizing and mapping ideas, reading multiple sources and adding information to their maps, writing and editing their reports, and revising them for publication); (d) sharing books or reports they had written in Sharing Chair; (e) journal writing; and (f) story response and book discussions related to the expository and narrative texts that composed the thematic units (Englert & Mariage, 1996; Englert et al., 1995; Englert, Mariage, Garmon, & Tarrant, 1998). Pedagogically, the ELP curriculum's design and implementation was also informed by five principles: (a) instruction should promote self-regulated learning; (b) instruction should be responsive to the needs, capabilities, and interests of learners; (c) literary instruction should scaffold performance in students' zones of proximal development; (d) instruction should represent the meaningful relationships that exist between oral and literate forms of discourse; and (e) instruction should emphasize membership in a literacy community (Englert & Mariage, 1996).

Several studies confirmed that the ELP curricular approach showed great promise in accelerating the literacy achievement of special education students with mild disabilities (Englert et al., 1998). Contrasts of the experimental and control students on a number of literacy measures showed that experimental students significantly outperformed controls in their lower- and higher-level skills, including their sight word recognition abilities, oral reading accuracy, comprehension, writing fluency, and expository writing abilities (Englert et al., 1996). Furthermore, in studies of specific school sites

where special education students received three or four years of instruction, the majority of students concluded the program reading above or within one-half year of their grade level placement (Englert et al., 1998). Thus, the project showed the potential to accelerate the literacy progress of students with mild disabilities.

Extending ELP: The Need for Technology

Although the ELP showed the significant effects of the literacy curriculum on the reading and writing performance of students, there were several issues that warranted extensions of the work into literacy applications involving technology. Specifically, there were four areas of the project that we thought might be enhanced through the use of technology.

First, progress was slowest among the youngest, lowest-achieving readers and writers in special education classrooms. Such students needed an even more concentrated set of experiences that might unify literacy instruction across the language domains (oral, listening, reading, and writing). We felt that computer technology could address these problem areas by bridging the language modes in a simultaneous and fluid way (e.g., what was written could be read; what was spoken could be written). Using speech-recording functions and text-to-speech (reading) functions, multimedia technology could be employed to enable children who were "nonreaders" and "non-writers" to receive the support and feedback they needed to be more active players in the literacy community.

Second, ELP students were limited to information in printed texts that were read either by the teacher or themselves. Thus, they were likely to see texts and teachers as the content authorities rather than themselves. On the other hand, we thought that technology could substantially increase students' access to information from multiple sources, including visual (images), aural (sound), and videotape sources that could provide cultural, social, and emotional information about topics of interest (Daiute, 1992).

Third, the ELP was confined to the learning community of a single classroom, which limited students' access to authentic audiences and constrained students' understanding of the authentic nature of the problem-solving communicative process in an academic community. With technology, we hoped to (a) provide functional and authentic purposes for gathering, manipulating, and integrating information from multiple sources, and authoring oral or written texts as part of a knowledge-construction process; (b) expand the classroom walls to include a larger, authentic audience of peers, teachers, and experts; (c) provide multiple ways to access, organize, visualize, link, and discover relationships among various sets of ideas; (d) engage students systematically in higher-order cognitive and literacy tasks in an inquiry-driven knowledge construction process; and (e) encourage fundamentally different forms of interactions and discourse among students and between students and teachers (Dwyer, 1994).

Fourth, the ELP depended upon discursive contexts where expert-novice apprenticeships were formed and where teachers modeled, constructed,

and guided children's literacy learning in socially constructed ways (Englert et al., 1994). However, it was difficult for teachers to scaffold students' performance on a moment-to-moment basis, or to prompt the use of strategies when students were writing independently. With technology, we hoped that teachers could provide prompts to students when needed in the contexts of reading and writing. The flexible nature of the technology could allow students to "grow out" of their dependence on prompts as they developed personal agency.

Affordances of the World Wide Web: Component and Connectivity Revolutions

Thus far we have discussed an existing practice and the perceived benefits that technology might have to enhance or extend the existing pedagogy. Many different applications of technology have been used to achieve what was discussed in the previous section: speech synthesis or multimedia to present information and texts in different modes, electronic mail for extending the community, Inspiration (Inspiration Software Inc., 1994) for mapping, Hyperstudio (Roger Wagner Publishing, 1999) for creating stories, and the World Wide Web for accessing diverse and updated information. As discussed earlier, every technology has its own affordances and constraints—each technology inevitably favors certain applications and inhibits others (Bromley, 1997). For example, a screwdriver works great with screws but not so well with nails. Most email applications (e.g., Eudora) are good for sending and receiving text email messages, but are not so good for word processing or accessing the Web.[1] Finding the most appropriate technology to realize the aforementioned goals was an important and complex component of the project framework. In the follow paragraphs we discuss why and how we selected the Web as the technology in terms of its affordances and constraints in relation to the literacy goals of the project.

When the TELE-Web project was initially conceived in 1994, the technologies considered to support the project were mostly CD-ROM based commercial software (e.g., the Living Books[2] series), StorySpace (Eastgate Systems Inc., 1999), ClarisWorks (Claris Corporation, 1995), and multimedia authoring tools such as HyperStudio. These tools, when pieced together, can provide the desired functions. But as Kaput and Roschelle (1996) point out:

> It is not enough, technologically, to simply assemble the loose pieces, since data cannot be moved easily among them. . . . A larger difficulty is the fact that each software system has its own file structure, which means that separate files must be maintained for each version of the data. Hence, a student's work associated with a particular activity is stored in a collection of files depending on the applications used rather than on the nature of the educational activity. Similarly, each separate software system controls the screen when it is active, so if one application is active, then any other applications sharing the same screen space are hidden behind it, and vice-versa. These limitations drastically narrow or fracture educational activities. (p. 7)

The Web seems to be a technology with the potential for avoiding the aforementioned constraints. Two features of the Web afford us what we needed for this project: component architecture and connectivity. The concept of component architecture is quite simple. It refers to a new approach to developing software. This approach provides a set of standards and a framework that allows multiple software systems to interact with each other, sharing data and utilizing each other's unique functions. Apple's OpenDoc and Microsoft's OLE are two systems that exemplify the concept. The Web is another example of component architecture. A typical Web page can contain text, graphics, animation, speech, and video. These different components can be produced with different software applications: a word processor or text editor for the text, a drawing program or graphic program for the graphics and animations, and an audio/video program to produce the audio/video files. They are then assembled dynamically to be presented in a single application—a Web browser.

There are three key benefits to Web-browser-based educational software. First, it is much easier and cheaper to produce the different components in this architecture than it is to produce them the traditional way. As developers, we do not need to write a single large and very complex system to handle text, graphics, audio/video, and speech-text conversion, since many special programs for those purposes already exist. We need only to find a way to make the programs work together, and the Web provides such architecture. For instance, in order to provide students the opportunity to access language in different modes, we need a system that, at the command of the student, will "read" or "speak" the student's written texts or other students' texts. To develop such a system would be quite difficult technologically and financially. Through Web technology, however, we are able to link Apple Computers' text-to-speech technology, Netscape's Web browser (Netscape, 1998), JavaScript (Netscape, 1997), and MVP Solutions' Talker (MVP Solutions, 1997) plug-in to enable that function. In fact, the whole system of TELE-Web that was eventually developed relies on component architecture. We discuss this system further in the next section.

Second, component architecture enables the presentation of content in an integrated fashion. Engaging students in a variety of activities, including reading, writing, researching, communicating, and drawing, is a significant aim of many existing literacy programs. Technologically, more than one piece of software is needed by teachers to support all these activities. Besides the problem of screen and data sharing across software programs and users, separate software requires that students and teachers learn to use the various software systems.

Using the Web reduces the number of things to learn, thus increasing the possibility that students and teachers will spend more time actually using the system (Zhao, 1998). This seems especially important in the case of students with disabilities, who have difficulty seeing the connections among the separate parts of a system and need more time in instruction rather than less.

Connectivity is the third feature that makes the Web a better choice of technology for the project. Connectivity relates to the capacity for communication among peers and between students and experts as students access information beyond the classroom walls, but also enables seamless data sharing across activities. The communication capacity of the Web is quite obvi-

ous, so we will only elaborate on its potential for sharing data across activities. Kaput and Roschelle (1996), in fact, suggest that one of the biggest problems with traditional educational software lies in the difficulty in exchanging data easily across the different systems. Students' data and finished work using one piece of software can not be easily retrieved for another activity using a different piece of software. For example, students might be reading the Living Books on CD-ROM, writing with ClarisWorks, communicating with Eudora, and making stories with StorySpace. Each system has its own way of storing data, making it difficult for the students or teachers to move back and forth among them. In the new system, all activities take place in one place—the Web browser—and all data are stored on a Web server, making it possible for students to link reading activity to writing, writing to drawing, and drawing to research activity, or vice versa.

At the same time, the Web also places a number of constraints on our design. First, it is a new technology. Many of its functions are still unstable and not as sophisticated as their stand-alone counterparts. For example, word processing is still quite rudimentary compared to many word processing programs (Microsoft Word, ClarisWorks, or WordPerfect). Drawing using Java Applet is also less impressive than most stand-alone drawing programs. Second, the Web requires a network, which may not be available to all schools. Third, the performance of the Web is determined by many factors (e.g., the server, the network, the local machine, the browser). Therefore it is much more susceptible to performance problems than stand-alone applications. For instance, when the server crashes, students cannot access the program at all and it is more difficult to fix; when a stand-alone program crashes, users can simply reboot the machine.

ELP Meets the Web: Shaping and Shaped by Technology

The Web is a flexible technology that is open to multiple interpretations and applications. In this project, the practices and principles of ELP shaped our interpretations of the Web, defining the Web as an environment for literacy development. At the same time, the affordances and constraints of the Web also influenced the realization of the curriculum, resulting in a Web-based literacy environment that was not exactly the same as the original ELP curriculum, and not even the one envisioned to be extended by CD-ROM technologies.

The literacy activities and principles of the ELP served as the basis for designing Web-based environments that incorporated the specific features of the prior project and that have been found to be effective in special education. Essentially, the technology application was designed to function as an intellectual tool for the learner, serving to stretch cognition between the learner and the machine, helping to off-load cognitive activity in the face of complexity, and providing strategies and representations to aid writing and reading processes. In the next paragraphs, we review the particular features of TELE-Web that made this possible.

TELE-Web: An Overview

TELE-Web consists of a set of server-side software and client-side plug-ins that work with a Web server and database applications to offer an integrated suite of multifunctional tools for teachers and students to use within a Web browser. It enables teachers to adopt, develop, manage, and share multimedia literacy materials, as well as to initiate, conduct, and manage collaborative learning projects. In addition, teachers and researchers can archive students' reading and writing responses in order to observe, monitor, and report students' literacy performance. Within this environment, learners are enabled and encouraged to explore, experiment, and experience independently and collaboratively with their peers from the same school or from a distant school. Tools are also provided to help students develop performative abilities in reading and writing, in addition to the metacognitive skills related to becoming goal-oriented, self-regulatory, independent learners.

Figure 1: Main menu: Publishing, Reading, Library, and Writing Rooms.

The TELE-Web environments are shown in Figure 1. There are four central environments that form the core of TELE-Web: the Writing Room, the Reading Room, the Library, and the Publishing Room. Each of these environments has both a teacher and a student interface, allowing teachers and students to create assignments and add on to or comment on other students' work; and permitting students to read stories. What is unique in these various environments is the opportunity for students to receive cognitive and social support in each environment, insofar as the cognition and cultural capital and artifacts are accessed and distributed among the users across the whole network in TELE-Web (Salomon, 1993).

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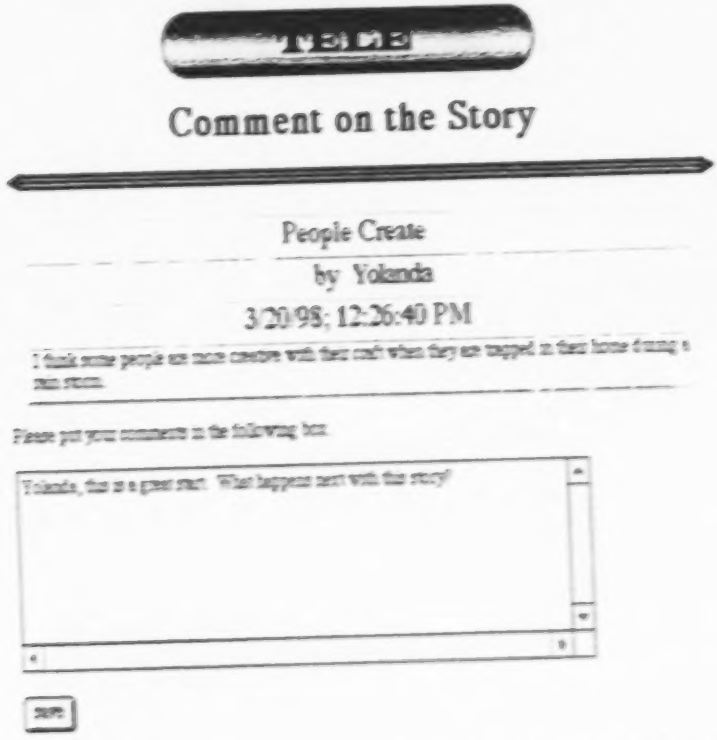
Student Interface

The Writing Room.

In the Writing Room, students can compose several types of text genres, including narrative (My Story), personal experience (Morning News), and descriptive/narrative (About a Picture). They can also choose to Continue a Story written by another student. Each time students write a story, they are given the authority to choose who can read their story (e.g., by identifying specific names of students, the entire classroom, other classrooms, or other audience members on the Internet). They can also consent or deny permission for other authors to add to their story. However, when students choose to publish a story in the database, it is available for comments or questions (see Figure 2). In this fashion, students are given power and authority in deciding the audience of their texts, and determining what actions their audience can take with their text.

Figure 2: Students can comment on or add to peers' work.


Comment on the Story
People Create
by Yolanda
3/20/98; 12:26:40 PM
I think some people are more creative with their craft when they are tapped in their home during a rain storm.
Please put your comments in the following box
Yolanda, that is a great start. What happens next with the story?
save

There are three features of the Writing Room that enhance its applicability to the literacy curriculum. The dual potential for collaboration and responding to texts in reciprocal ways allows teachers to build ever-widening *reciprocal learning communities* and *funds of knowledge* for writers. Children can elaborate upon or continue each other's stories in a reciprocal way, or provide feedback or information to an author as they present their own intellectual capital and a fund of knowledge for others to access. The opportunity to learn and be informed by the multiple perspectives and cultural

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expertise of others is an important facet of the program, especially for students with disabilities. The publication of stories on the Internet has the potential to provide authors many virtual writing and cognitive partners as audience members from distant geographical locations use the comment function on TELE-Web to ask questions, redirect thought, provide new interpretations, activate the retrieval of knowledge, provide scaffolding, or engage in sense-making. Essentially, the Web-based software opens up new opportunities for apprenticeships, where students can be supported by others while learning how to actively use their knowledge to compose and monitor their texts. Simultaneously, children with disabilities are positioned as authors, experts, and critical thinkers within and outside their classroom walls.

Second, the Writing Room, like all the rooms in TELE-Web, supports the development of reading and writing skills through an emphasis on the integration of language modalities (e.g., speaking, reading, writing, listening). Although we had originally envisioned using CD-ROM talking books to support beginning readers, the opportunities to have simultaneous access to oral (aural) and written (visual) texts on TELE-Web makes it an ideal environment for beginning readers and writers. With the click of a button, the computers can give immediate assistance and provide the reader or writer with help on words that are difficult, furthering students' development of word recognition skills, reading fluency, and the development of an awareness of sound-symbol correspondences (Jones, Torgesen, & Sexton, 1987; Roth & Beck, 1987). Applying this technology to their own or other's written texts, children with mild disabilities can use the text-to-speech function to identify and correct significantly more punctuation, spelling, grammatical, meaning, and syntactical errors (Espin & Sindelar, 1986; Raskind & Higgins, 1995). The immediacy of speech feedback for words and discourse can mirror the real-time language processes of reading written texts with the additional advantage of providing readers and writers with information about the oral, linguistic, phonemic, and graphic features of the words in the oral/written discourse. In essence, the computer is "shaped" into an on-site reading tutor, providing immediate assistance upon demand.

Finally, the TELE-Web writing environment has a teacher interface that allows teachers to develop and deliver writing prompts to assist writers during the writing process. Students with learning difficulties are often lacking self-regulatory (metacognitive) mechanisms, which are extremely important to problem-solving in complex ill-structured domains such as writing. The TELE-Web environments provide teachers with the option of customizing particular assignments for a student or group of students by writing specific prompts that might cue strategies or regulatory processes. For example, teachers could generate computer-provided metacognitive questions to scaffold the performance of students as they compose a story narrative (e.g., Who is the main character? What is the setting? When does the story take place? What is the problem? What does the main character do to try to solve the problem? What happens?) or a personal experience story (e.g., Tell Who? When? Where? What happened? Give details).

Writers then can choose to see these prompts as they plan, compose, or edit their stories. In this way, teachers and children can off-load the cognitive burden of cueing or remembering strategies onto the computer (Salomon, 1993). Technology is assigned the function of being the repository of cogni-

tion and thought by the teacher or students that can be later accessed by writers to mediate performance (Salomon, 1993). Practically, the computer technology becomes a type of partner for the student, providing supported situations and distributing the intellectual work or strategic performance to help children perform more complex processes than their current knowledge and skills alone might allow (Salomon, 1993).

The Library Room.

The Library Room provides a different but coordinated set of functions that are also intended to scaffold the performance of children with disabilities. When children enter the library room, they have a choice of three environments: making reference notes, creating semantic webs or maps, and recording conceptual vocabulary. All of these are designed to support the development of learning-to-learn processes by providing access to representational systems to aid students in the archiving and retrieval of ideas, as well as facilitating the organization of their knowledge into conceptual and scientific frameworks.

Figure 3: Notes can be searched and listed in a table for readers to annotate.

For example, in selecting TELE-Web Notes (Figure 3), children can produce notes and enter their notes in a database that can be accessed by other children, as shown in Figure 4. As in any referential system, they can assign their notes salient keywords by which their ideas can be tagged and retrieved. Upon retrieval, the notes can then be added to or edited by the author. Other students can access these notes or respond to them with their own questions or contribute to the growing database by appending information

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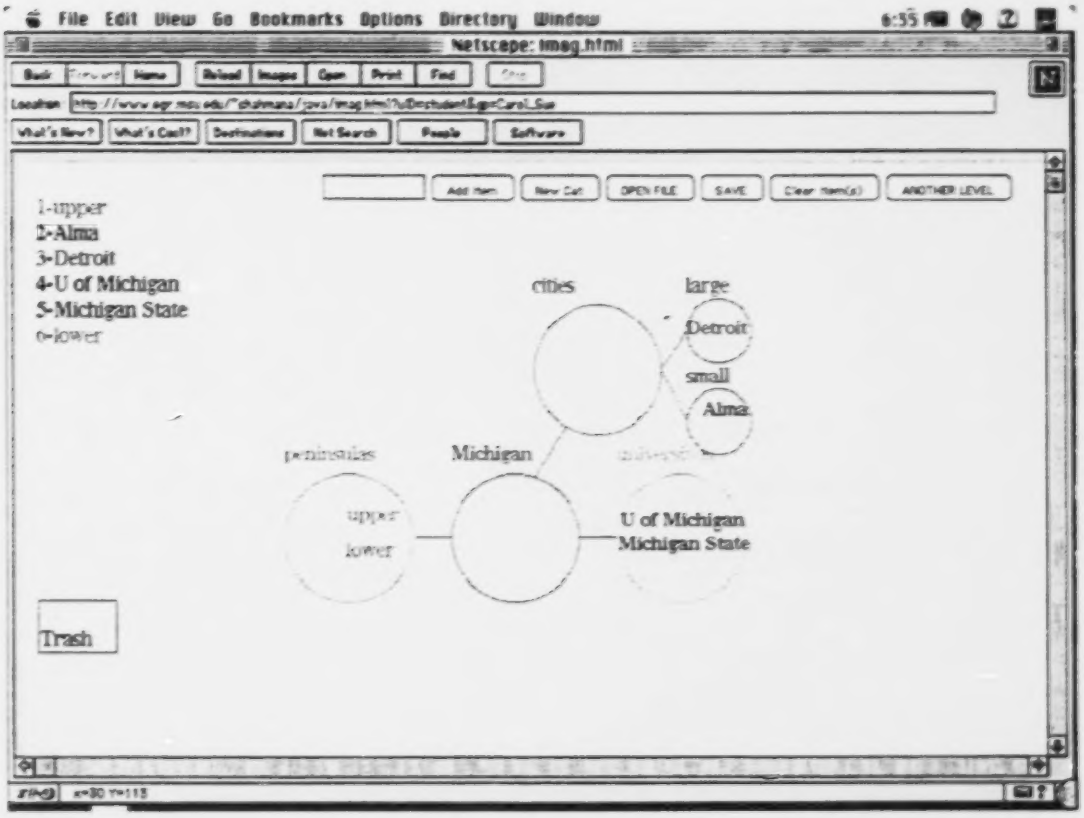
related to the topic. TELE-Web, therefore, can provide a shared workspace where students can post ideas and use each other as teachers, reviewers, and critics. In this way, the information available about a particular topic can exceed a single individual's knowledge, since it integrates the collective funds of knowledge of the various participants in the group and incorporates questions that provoke deeper inquiry and investigations. Unlike many school situations where students work in solitary contexts, TELE-Web enables a collaborative forum that can bring together diverse partners from around the world in educational inquiry.

Figure 4: A screenshot of one mapping tool in TELE-Web.



There is also a suite of tools to support the deeper representation of children's knowledge into conceptual models through the mapping functions of TELE-Web. There are six different types of maps, ranging from Venn diagrams, to semantic webs (One-Level Web, Multi-Level Web), to story maps, to explanation maps. Each map represents a conceptual procedure or representational structure of information (see Figure 4). Students can define information categories, input information items, and rearrange the information items by dragging and dropping them into the desired category. In addition to the predefined structures, an open drawing and mapping tool is also available. Children can draw pictures of their ideas, which is ideally suited for nonwriters, as well as for learners who need to represent the results of scientific inquiry through drawings.

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Importantly, the webs and maps become the means for teachers to "intellectualize" cognitive activity. The maps provide an anchor or linchpin for creating a collective knowledge that can guide intellectual activity and for the participation of students in a discourse about the structures of informational texts. In effect, cognitive functions regarding categorizing ideas can be offloaded onto the webs until the time that students can perform the cognitive actions of organizing ideas into texts or composing organized texts without visible or symbolic representations of the process. Thus, the webs serve to scaffold mediated performance in the students' zone of proximal development (Vygotsky, 1978)—that is, the distance between students' independent performance and the level of performance achieved with the benefit of the webs and the social interactions with other members of the class.

Maps created with Java applets then can be distributed across the Internet. Students and teachers can create, edit, or discuss the maps collaboratively across time and space. The maps can be used to not only support discourse development but also trigger new discourses. In other words, students from different groups can use the mapping functions as cognitive tools to record, organize, and represent their ideas and access them when needed. By sharing or collaboratively creating maps, students can exchange ideas, clarify confusions, and explore new possibilities. The communications about or around the maps become important authentic writing and reading activities for literacy learners that engage them in a more critical discourse about ideas and meanings.

An additional form of scaffolding comes from the community. Gardner (1991) writes about the benefits of bringing the outside world into the classroom; "a myriad of educational opportunities exist in the wider community, including apprenticeships, mentorships, and other relations with competent professionals" (p. 104). Information networks are important features of knowledge-building communities that have been incorporated into TELE-Web. This feature enables participants to create authentic linkages between knowledge-creating and knowledge-commenting communities. The current emphasis on authentic and situated learning has pushed the envelope on our conceptions of what constitutes an effective learning community in a classroom: in-depth problem-solving; working collaboratively with peers or partners in problem-solving inquiry; learning about topics or problems of personal interest; constructing and disseminating knowledge; serving as guides, mentors, and apprentices to others; and using information systems to access and contribute to the knowledge base. Nevertheless, to ensure that students maintain a central role in producing rather than digesting knowledge, contacts with outside sources need to be established and maintained, and a scientific discourse needs to emerge in the context of the obtained information. Restructuring schools requires attention to ways that students can increase their knowledge-building potential (Scardamalia & Bereiter, 1994).

Two mechanisms for advancing collective knowledge in the scientific community are the scientific journals and information systems that allow for peer review and comment (Scardamalia & Bereiter, 1994). Although knowledge-advancing and knowledge-commenting forums do not routinely exist in schools, TELE-Web allows students to create texts, graphical notes, and maps that are added to a collective database about topics of personal interest. The transformation of traditional patterns of solitary thought into a more

collaborative scientific discourse is further enhanced by the following features (see Scardamalia & Bereiter, 1994): (a) recognition of students for their personal expertise and contributions as authors of a database; (b) simultaneous access to other students' maps and entries; (c) provisions for students to search, question, or comment on an author's notes, map, or graphic; (d) notification of authors when comments are made by other students; and (e) the construction and eventual publication of entries that can become part of a larger and more diverse scientific community that might bring like-minded investigators together though the Internet (Scardamalia, 1994). Through these features, TELE-Web makes it possible for metacognitive activities to be overt and subject to public discussion and consideration, and creates authentic networks in which students create and exchange knowledge.

It is important to mention that the different rooms in TELE-Web are interconnected and mutually accessible. All tools in the Library Room are readily accessible from the Writing Room or the Reading Room. In fact, students are encouraged to consider the Library Room as a reference place where they can store and share rough ideas, action plans, or other kinds of intermediate products with their colleagues. For example, when a student is in the Reading Room reading a story, she can open the communal notebook and file some notes. Or when a teacher starts a thematic unit on animals, she can use the mapping functions to work on the main concepts with her students. Later, when the students start to write, they can refer to the notes and maps.

The Reading Room.

TELE-Web also contains a reading room where students can engage in a host of reading activities. Realizing that there is more than one effective strategy for reading success, we have included over 15 different types of reading activities that are purported to be effective in ELP and other literacy research. These activities are placed in three sites: Comprehension, WordShop, and Book Chat. The Comprehension site provides reading activities that target meaning at the text level. For example, there is a Cloze activity that allows the student to work on a text by filling out the words deleted by the computer. The student decides the interval of deletion and the starting point of deletion, and can therefore make it easy or hard. Cloze procedure has been alleged to be a very effective strategy in language development (Oller & Jonz, 1994). The Cloze activity can be easily correlated to a particular reading series, piece of literature, or story. Other comprehension activities include Paraphrase the Story, Paragraph Scrambler, Reading Comprehension Story Map, and Continue the Story.

Activities in the WordShop focus on developing skills at the word level. Typical activities include Create a Word, Letter Scrambler, Crosstik, and Spelling. All activities in the WordShop, as in other places within TELE-Web, are highly individualized. For instance, Spelling utilizes speech-to-text technology to provide highly individualized exercise for students. A teacher can enter a list of spelling words and sentences for a student or group of students who will then complete these on the Web. To complete this exercise, the students click on a button to listen to the spoken form of the word and then write it down in the text field on the Web. The student then sends his answers back to the server for feedback. The system also keeps track of the performance of each student so that teachers can be informed of the words that are problematic to certain students.

Book Chat is a Web-based chat system that enables students to have synchronous communications with people at a distance or just in the same classroom in writing. Students discuss books they have read in Book Chat.

There are four unique features of the Reading Room of TELE-Web. First, the materials to be used in the reading activities are not limited. Unlike most traditional reading software, TELE-Web allows teachers, and even students, to input their own reading materials into one central online database. All users of TELE-Web can contribute materials to the database. Materials are labeled in terms of grade level, genre, and possible reading activities. Contributors are also encouraged to rate the material, and determine who can use their materials. This means that the materials to be used in TELE-Web can be individualized and updated more frequently than traditional reading software. The second feature is that all reading materials in TELE-Web can be used across activities. In other words, a passage can be used for Reading Comprehension, Cloze, Paragraph Scrambler, and Continue the Story. Thus students can work with the same text in different ways. The third feature is that reading activities are closely linked to other activities. For example, while a student is reading, he can access the TELE-Web Notes, writing down his thoughts in them to access them later or share them with other students. He can also access the mapping tools to draw concept maps of what he is reading. The fourth feature is that students can create reading activities for each other using the materials in the database on the server. For instance, a student, just like a teacher, can develop a reading comprehension exercise for his peers within the same class or another class that is also using TELE-Web.

The Publishing Room.

As its name suggests, the Publishing Room provides a set of tools for students to publish their work. There are a number of templates and a suite of tools for students to develop a portfolio of their work within TELE-Web and publish it on the Internet. Because TELE-Web is a closed environment, only people with the proper authorization can enter the environment to access students' work and communicate with them. This feature is a double-edged sword. On the one hand, a closed environment provides a sense of community and protects the young TELE-Web users. On the other hand, it prevents other people on the Internet from visiting our students' work. To compensate for this shortcoming (Levinson, 1997), we developed this publishing component. In the publishing room, students can enter pictures, tell stories about themselves, and assemble works they have done in other rooms. Anyone on the Internet can visit the published works of students but they do not have access to the students' real names or email addresses. This preserves the anonymity of TELE-Web students.

Teacher Interface

TELE-Web also features a teacher interface that allows teachers to create and customize assignments for individual students. The teacher interface of TELE-Web provides a series of tools for teachers to create literacy activities that will appear in the student interface. We use the Writing Room as an example.

TELE-Web enables teachers to make highly individualized writing assignments for students. Upon entering the Writing Room, teachers are greeted with the same four choices outlined in the discussion of the student inter-

face of the Writing Room. My Story, Morning News, About a Picture, and Continue A Story each represent one type of writing assignment they can create for students. By choosing one of the links, teachers are presented with a list of existing assignments, and the option to create a new assignment. With existing assignments, teachers can choose to provide feedback to students' completed assignments. In addition, teachers can choose to edit an existing assignment, which allows them to change due dates, assignment titles, and names of students for whom the assignment is developed. When teachers choose to create a new assignment, they are asked to provide a title for the assignment, select a date when the assignment will be automatically made accessible to the students, and select the students who should complete the assignment. Only students who are selected to have access to this assignment will see this assignment when they log in. Teachers then provide the content of the assignment (e.g., prompts and instructions). Teachers can also include other Internet sources as part of the exercise by providing a simple link.

In the other rooms, teachers have similar tools for developing, editing, and managing a variety of literacy activities. Additionally, teachers are provided with tools to collaborate with other teachers by sharing reading materials, exercises, or concept maps. They can also initiate collaborative projects across classrooms among students.

Discussion

Thus far we have described a seemingly linear and rational process of design: we had the goal to teach students to read and write, we had an idea for some good approaches to reaching the goal (ELP), we looked around for technologies to implement the approaches, and then we developed a software application (TELE-Web). In reality, this process, of course, was neither linear nor completely rational. As discussed at the outset of the paper, technological innovations and educational practices always interact with each other in a reciprocal manner to define and redefine each other. The final TELE-Web product testifies to that, as does the design process of TELE-Web.

TELE-Web is the result of a very active process through which existing educational practices (ELP) selected, defined, and shaped technology. It was the original goals and structures of ELP that significantly affected many of our decisions regarding what technology to use (stand-alone applications vs. the Web), how the different components should be assembled, and what interface the software should have.

It was ELP that provided the conceptual framework and context for designers to shape computing technologies in general and the World Wide Web in particular into a tool for literacy development. While computers and the Web have the potential to do and be many things, ELP helped to turn them into a special tool for special purposes. However, this is not to suggest that technology is an obedient slave to the pedagogical master. Instead, we found that technology did not just transfer ELP faithfully into a computerized ELP.

It transformed ELP in many ways. As a result, looking at TELE-Web, one can see both ELP and the Web, but it is not exclusively either.

The process of taking a theory or existing practices and converting them into a piece of working software is not a rational or simple process (Mishra, Zhao, & Sophia, in press). Any given theory or existing pedagogy can have multiple representations and instantiations depending on the context, available technology, knowledge of the designer/developer, the social dynamics of the design team, and the even the idiosyncratic personalities of designers. Similarly, technologies, particularly computing technologies, can have multiple instantiations too. A computer can be a word processor, a music CD player, a calculator, or a communication tool. TELE-Web, for example, is only one instantiation of ELP. Many events along the way might have influenced the look and feel of the product: the development of the Web and its associated functions, the developers' familiarity with CGI and Web servers and more powerful authoring tools, and the developers' and practioners' theoretical orientation to literacy development and instructor. TELE-Web represents the intersection of many influences upon the development and implementation process. Simultaneously, TELE-Web had a recessive, bidirectional effect on development as the mediated TELE-Web products modified the environment and the developers. Both the literary and technology experts acquired new understanding as their dialectical partnering came to be transformed into a new technological medium that represented new social practices that bridged literacy, special education, and technology.

Notes

1. This example does not apply to integrated packages, such as Netscape Mail. The software industry seems to be moving toward integrated applications that merge the traditional division of word processing, telecommunications, graphic manipulation, data management, and presentation. This example only applies to programs available as of 1998.

2. Living Books is a series of multimedia stories published on CD-ROM by Broderbund. More information can be found at http://www.broderbund.com/education/programs/livingbooks/.

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About CIERA

The Center for the Improvement of Early Reading Achievement (CIERA) is the national center for research on early reading and represents a consortium of educators in five universities (University of Michigan, University of Virginia, and Michigan State University with University of Southern California and University of Minnesota), teacher educators, teachers, publishers of texts, tests, and technology, professional organizations, and schools and school districts across the United States. CIERA is supported under the Educational Research and Development Centers Program, PR/Award Number R305R70004, as administered by the Office of Educational Research and Improvement, U.S. Department of Education.

Mission. CIERA's mission is to improve the reading achievement of America's children by generating and disseminating theoretical, empirical, and practical solutions to persistent problems in the learning and teaching of beginning reading.

CIERA Research Model

The model that underlies CIERA's efforts acknowledges many influences on children's reading acquisition. The multiple influences on children's early reading acquisition can be represented in three successive layers, each yielding an area of inquiry of the CIERA scope of work. These three areas of inquiry each present a set of persistent problems in the learning and teaching of beginning reading:

CIERA INQUIRY 1
Readers and Texts

Characteristics of readers and texts and their relationship to early reading achievement. What are the characteristics of readers and texts that have the greatest influence on early success in reading? How can children's existing knowledge and classroom environments enhance the factors that make for success?

CIERA INQUIRY 2
Home and School

Home and school effects on early reading achievment. How do the contexts of homes, communities, classrooms, and schools support high levels of reading achievement among primary-level children? How can these contexts be enhanced to ensure high levels of reading achievement for all children?

CIERA INQUIRY 3
Policy and Profession

Policy and professional effects on early reading achievement. How can new teachers be initiated into the profession and experienced teachers be provided with the knowledge and dispositions to teach young children to read well? How do policies at all levels support or detract from providing all children with access to high levels of reading instruction?

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